50th Annual Fuze Conference
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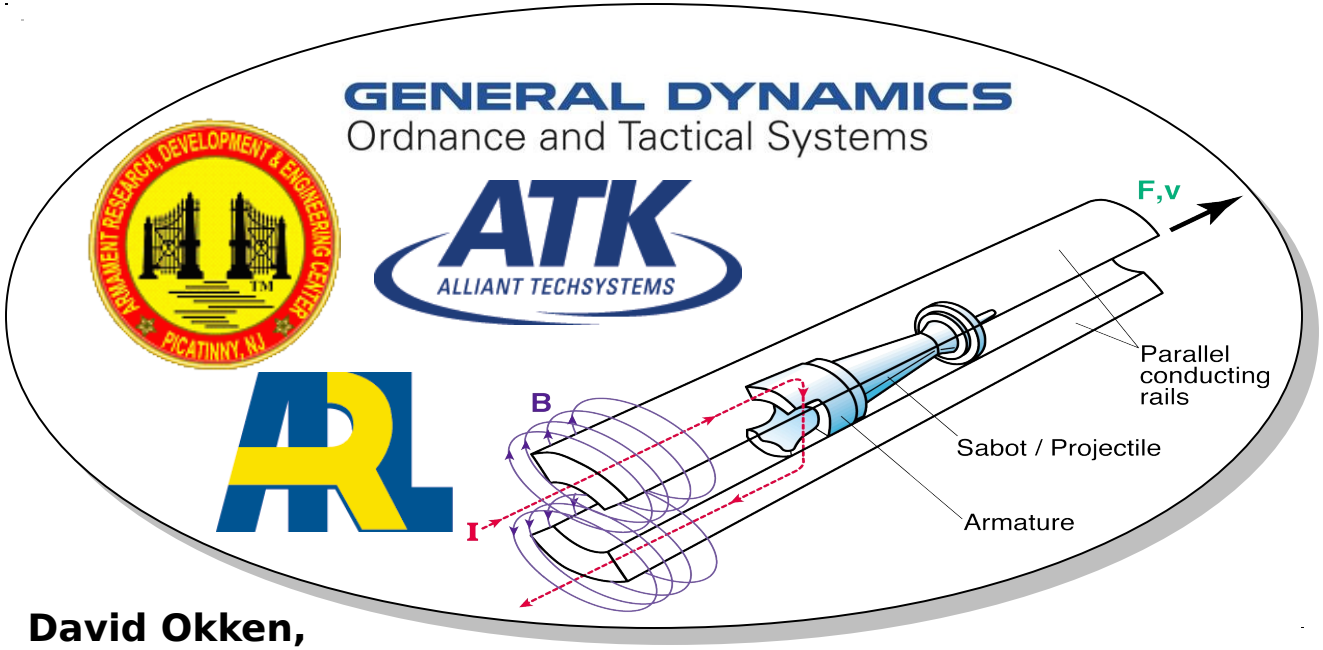
A Novel Fuze for Use in an EM Gun Projectile

Presenter:
Barry Schwartz
ARDEC
Picatinny, NJ



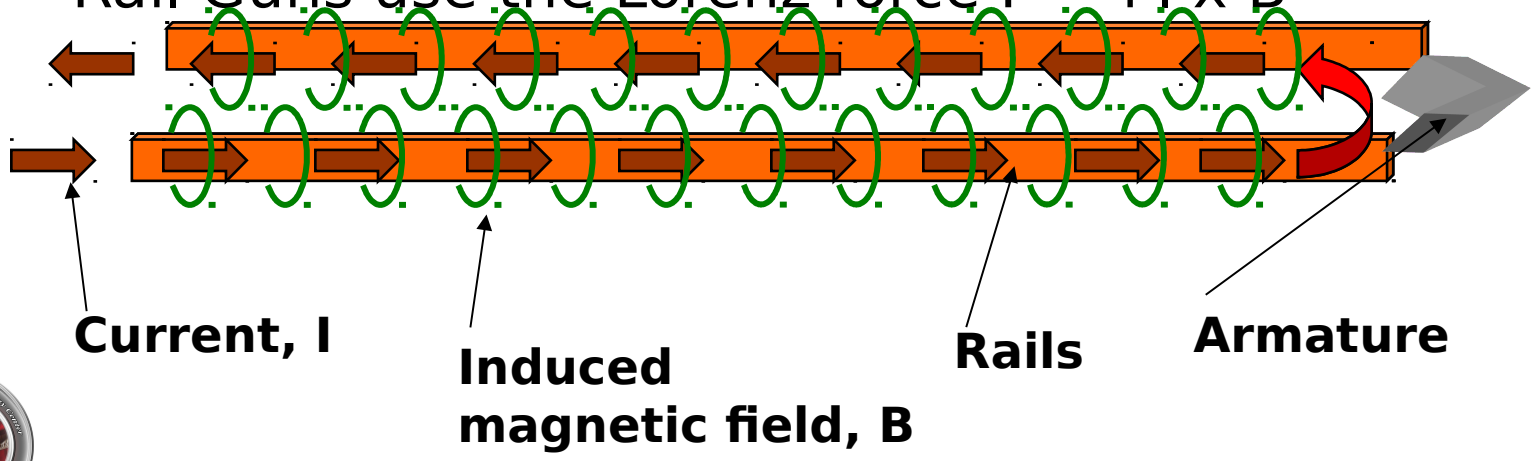
Authors:
ARDEC: **Barry Schwartz, David Okken, Justin Rhodes, Robert Bryan, Vinod Nagori**
ATK: **Eric Quist**

Background

- EM guns have been studied for many years
- EM guns have theoretical benefits over powder guns
  - hypervelocity launch
  - simplified logistics
- Advances in pulsed power technology prompted this ARDEC ATO effort to launch HE projectiles from an EM gun

EM Guns

- There are several types of EM guns or launchers, rail guns and several different coil guns.
  - Rail guns are the simplest the most mature launchers
    - Our effort is directed at using a rail gun
- Rail Guns use the Lorenz force F = i l x B



Integrated Launch Package (ILP) System Approach

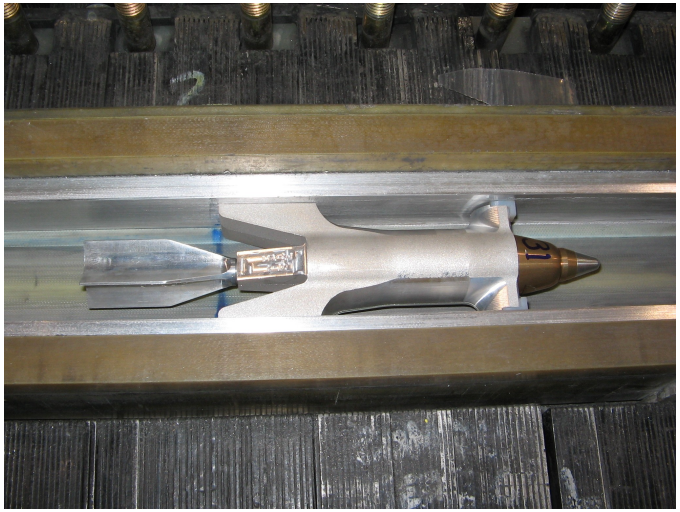
- **Objective:**
  - Demonstrate launch of an HE ILP from an EM Gun
    - Integrate a sabot/armature, flight body, fuze, and HE for demo
- **Approach:**
  - Test from ARL ½ MJ Electro-Magnetic Gun
  - ARDEC design, GD-OTS & ATK for Hardware Mfg
  - Team intellectual collaborative effort between government and Industry
- **Technology Challenges:**
  - Can large body, fin stabilized sub-projectiles be launched with significant lateral loads and high current environment?
  - Can high explosive & fuze survive the high current, and magnetic fields in this environment?

Fuze Approach

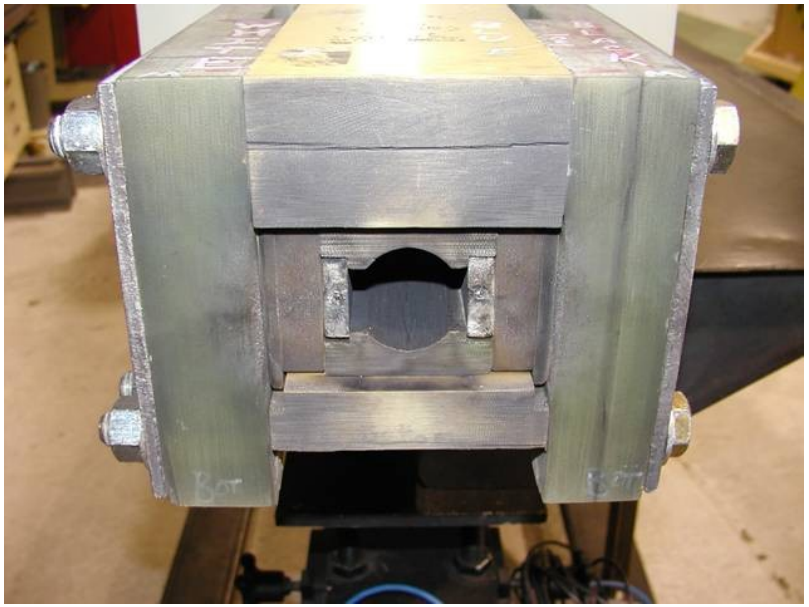
- Design an all mechanical, dual safe PD fuze that uses EM Gun launch environments to arm
  - S&A portion of fuze could be used in future EM Gun fuzes
  - ARDEC concept and initial solid model
  - ATK built hardware
- Investigate the survivability of typical fuze electronics and EED's in typical EM launch environment
  - Determine feasibility of developing an electromechanical fuze

Test Launcher: ARL ½-MJ EM GUN

- ***Max Muzzle Energy = ½ MJ***
- ***Peak Current = 1MA***
- ***Gun Length = 2.8 m***



Test Launcher w/ ILP



Muzzle View

Gun Cross Section = 22mm x 44 mm
Scalloped Insulation Cross-Section area = 38 mm (diameter)

HE Integrated Launch Package, ILP (the projectile)

- 24.4 mm diameter sub-cal projectile
- Aluminum armature incorporated into rectangular sabot
- Nose fuze ~70mm forward of armature

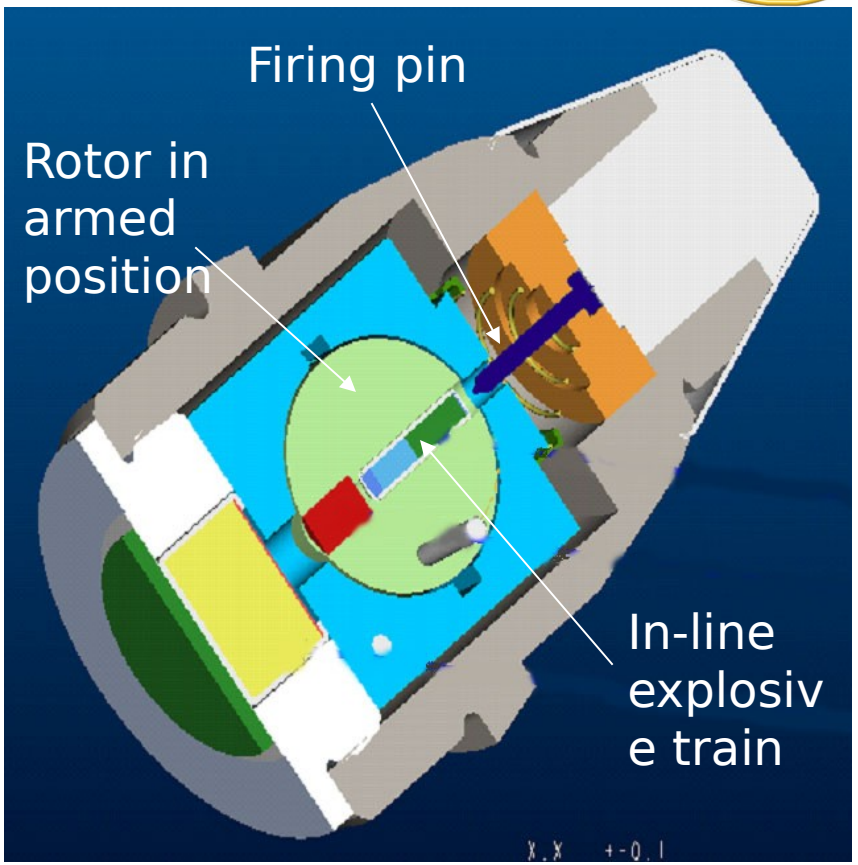
Launch Environment

- Setback ~ 50-60 kGs
- Magnetic Field
  - Changes with current, position and configuration
  - ~ 0.2 Tesla peak at projectile nose for 50kG launch
- Transition & Balloting loads
  - Transition – sudden rise in armature/rail interface and system voltage
  - Transition energy thought to cause balloting
  - Balloting estimated at 20% peak setback
    - Balloting oriented rail to rail

EM Gun Magnetic Field Profile

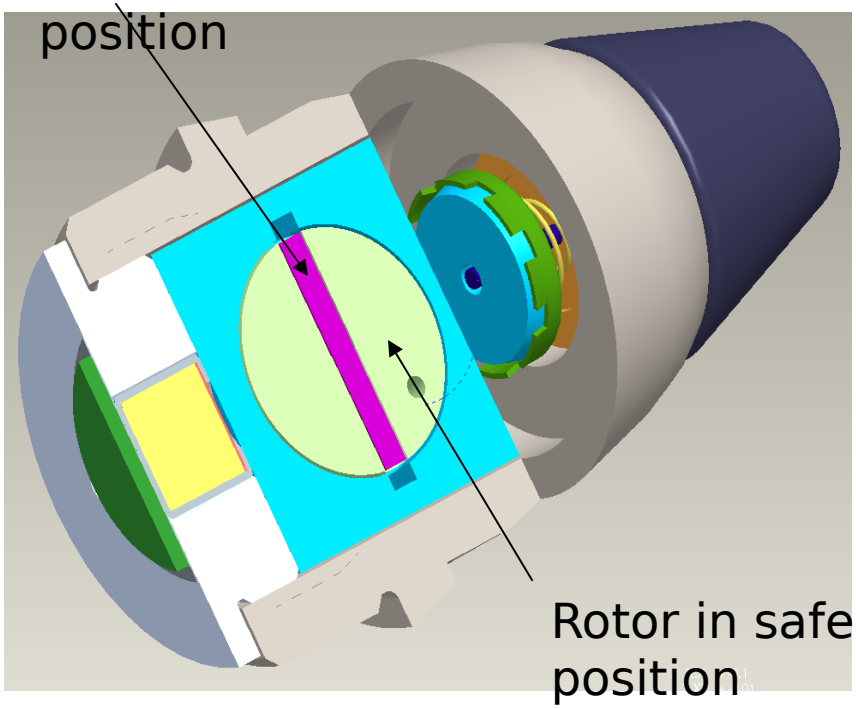
Mechanical EM Fuze

- Arming environments
  - Setback
  - **Magnetic (B) field**
- Energy to arm derived from setback
- Function modes
  - PD
  - Inertial graze



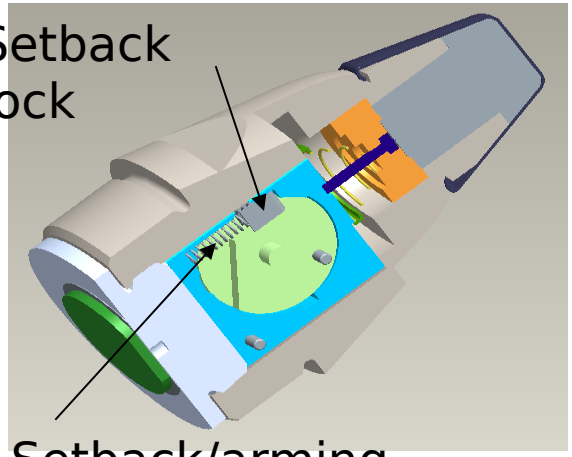
Magnetic Lock

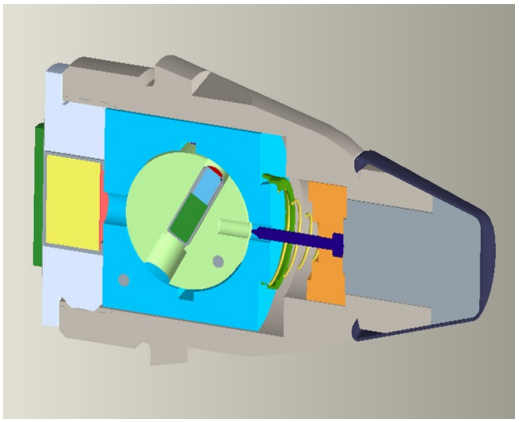
- Repelling magnets in rotor
  - **Extend past OD to lock rotor**
- Magnets aligned with **launch B field**
  - **Fuze clocked to sabot**
  - **rectangular sabot/launcher provides proper orientation**
- At launch, B field re-polarizes 1 magnet
  - **After launch magnets attract**
  - **Rotor released**



Setback, Arming & Initiation

- Setback lock blocks rotor in forward position
- After setback, setback spring becomes arming spring
- Firing pin prevents rotor movement until after launch
- PD mode firing pin driven aft
- Graze mode – rotor moves forward into firing pin





Fuze Testing Performed to Date

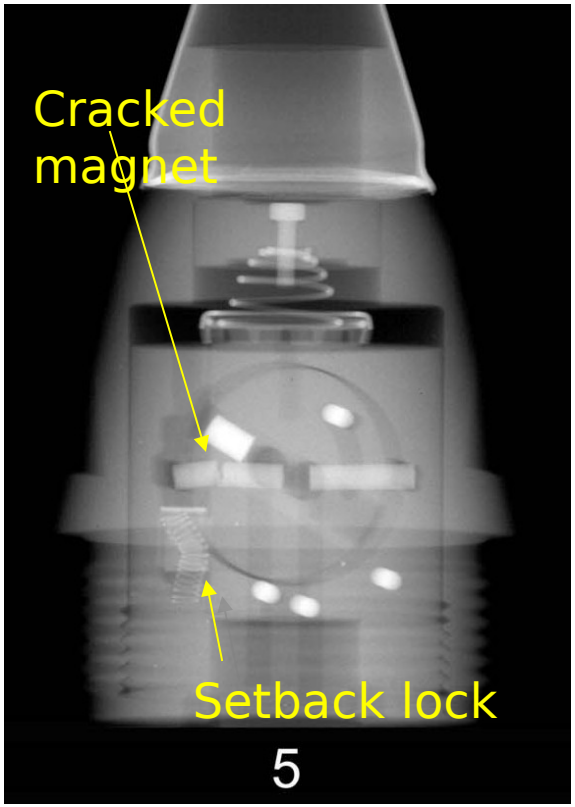
- Magnetic arming
- Airgun testing
- Vibration & 5’ Drop
- Magnetic strength
- Centrifuge arming
- In-line explosive & Out-of-line explosive
- Ballistic recovery

Magnetic Testing

- Fuzes tested in “H” fixture
  - “H” fixture simulates ballistic EM field
- Magnets repolarized and attract after test
  - Confirmation the magnetic lock can work in the fuze as positioned and configured
- Energetics, including primaries, survived
  - No magnetic induced ignition
  - Explosive train functioned post test

Airgun Testing

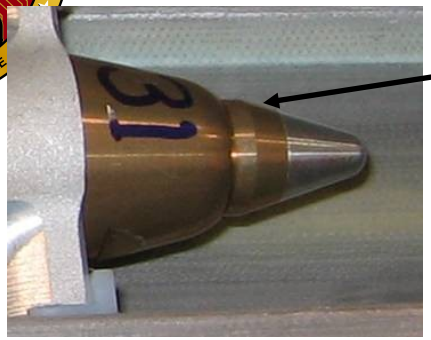
- 6 fuzes tested
  - 3 live 3 inert
    - **Inert fuze w/o magnets**
  - 47 to 62 kG
- 3 inert fuzes armed
- Magnet lock kept 3 live fuzes in safe position
- 1 of 6 magnets cracked
  - Magnet failed at 58 kG
  - Void found in failed magnet
  - Magnets inspected for surface flaws



Live airgun unit

Post test

Ballistic Soft Recovery



Pre-shot Hardware

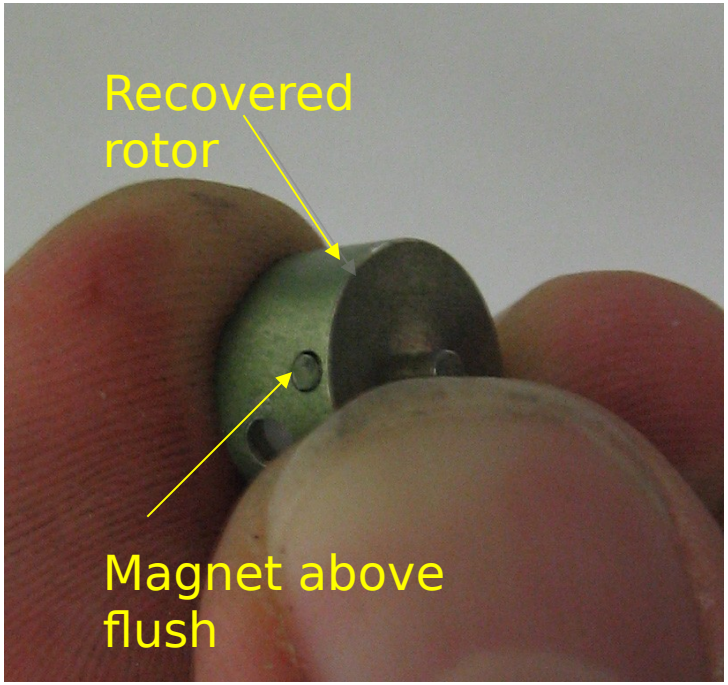
Recovered Hardware

- Seven ILP's fired with fully functional inert fuzes
- Nose modified to minimize blunt impact

- Target of foam and fiber board in a plywood frame
- All seven fuzes showed minimal impact damage

Results of Soft Recovery

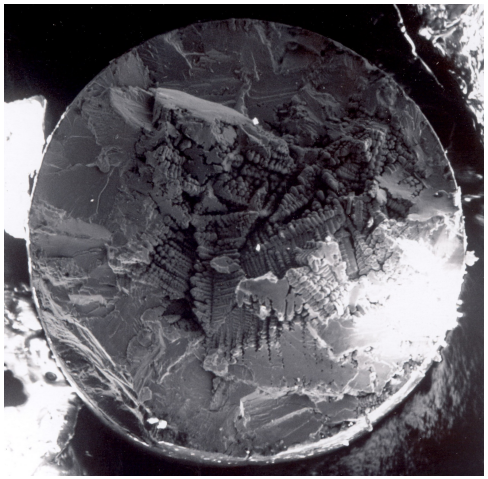
- Recovered fuzes showed little damage
- All setback pins moved down and arming springs cocked



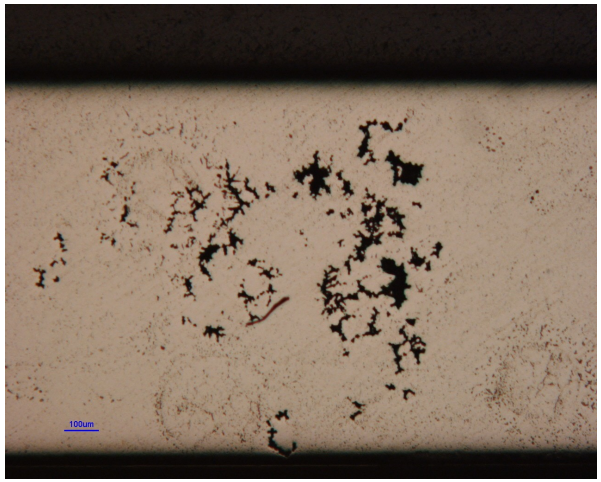
- Magnets were remagnetized and attract
- All magnets fractured into at least two pieces
- Irregular shaped surfaces prevented full retraction

Magnets Up Close

- Fractured magnets were examined and found to have voids in areas of failure



Recovered magnet



Sectioned magnet

- Magnets were sectioned and found to be highly porous
- Magnets to be sheathed for next test

Summary

- An EM gun magnetic field can repolarize magnets for use as an arming environment
  - Opposing magnets can function a safety mechanism
- Conventional HE fired from EM Gun environment without incident
- A 2nd iteration of fuze hardware will address noted testing deficiencies
- System integration
  - Integrate live fuze with ILP containing HE planned